National Aeronautics and Space Administration

Carbon Nanofiber Electrode Development for Cholesterol Detection

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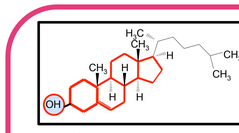
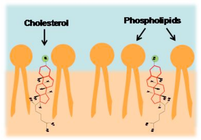
Abstract

Cardiovascular diseases, caused by high level in cholesterol, are increasing day by day and cardiac arrest is the major cause of death. Cholesterol and its fatty acid esters are one of the main constituents of mammalian cell membranes. The development of a biosensor that integrates cholesterol oxidase for the detection of cholesterol is important as a diagnosis tool. We propose to use a method previously reported by the Nanotechnology group at NASA-Ames Research Center for the fabrication carbon nanofiber (CNF) electrodes. This will involve a direct growth of CNFs on a metallic surface. This approach not only improves the electrical contact between the active sensing material (CNFs) and the conducting substrate, but also ensures that the sensor is free of impurities. The advantage of this technique is that the tips of the nanofibers are exposed to the analytes and the CNFs are vertically aligned for the attachment of cholesterol oxidase. The CNFs serve as the immobilizer and the mediator, at the same time. Different electrochemical and surface characterization techniques are used to characterize the CNF development such as: Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS), Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM), which we can provide information about the conductivity of the surface, the topology and the composition.

Overview

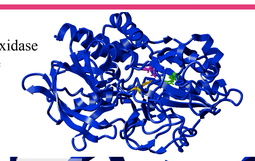


Cholesterol Molecule

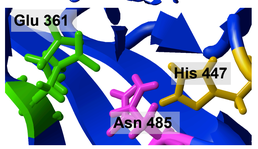


Cholesterol Oxidase
Molecular Weight = 55kDa
Acidic = pI 4.4-5.1
Most commonly isolated from:
Sterptomyces hygroscopicus (SCO)
Brevibacterium sterolicum (BCO)
Residues of the Active Site: His 447, Glu 361 and Asn 485

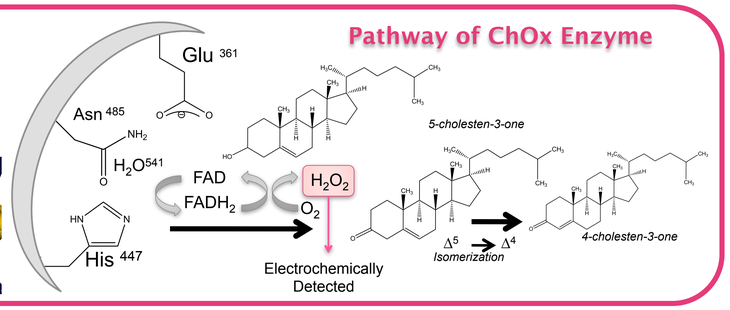
Cholesterol Oxidase Enzyme



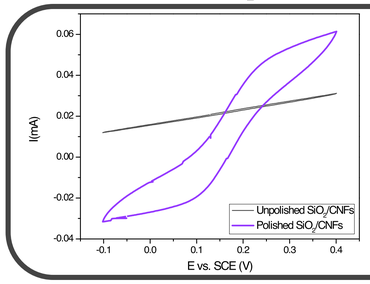
Cholesterol Oxidase Active Site



Pathway of ChOx Enzyme

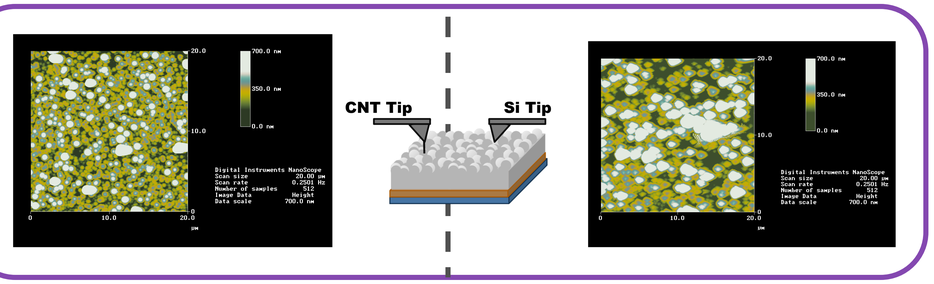


Cyclic Voltammetry of Polished and Unpolished SiO_2/CNFs Samples

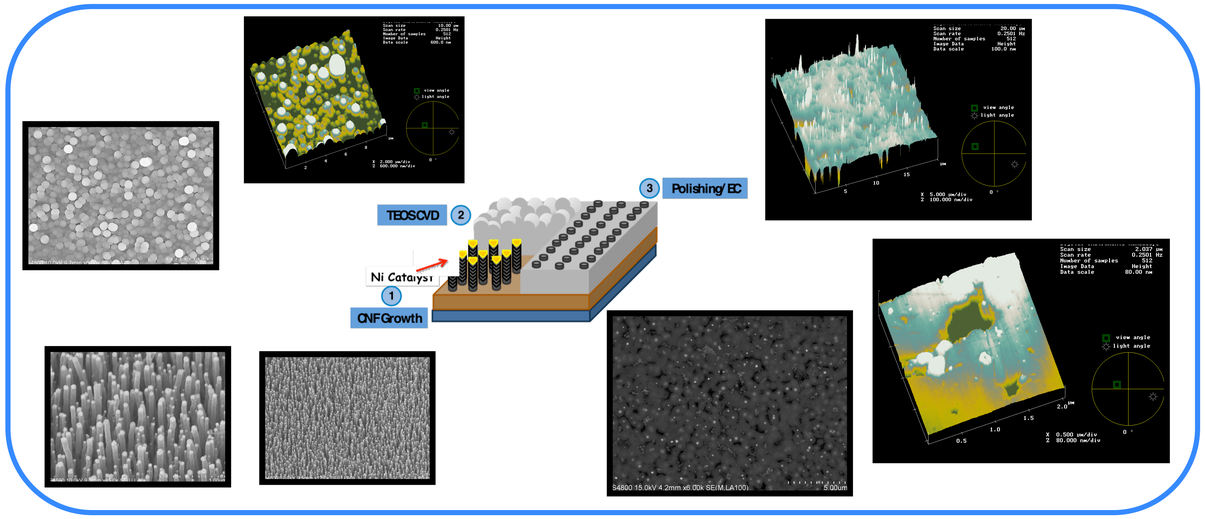


Cyclic Voltammetry of Polished and Unpolished SiO_2/CNFs Samples in 2.5 mM $Fe(CN)_6^{+3/+4}$/ 0.1M KCl. Scan Rate 100 mV/s

AFM Carbon Nanotube (CNT) Tip vs. Si Tip for (a)Polished and (b)Unpolished Sample SiO_2/CNFs



Surface Characterization Results: AFM and SEM



Conclusions

This worked show the preparation and characterization of CNFs. Cyclic voltammetry of unpolished samples shows no current for the oxidation an reduction of the redox couple $Fe(CN)_6^{+3/+4}$, on the contrary the Polished samples shows redox peak for the sample redox couple. This means that the carbon nanofiber are exposed. Also, from the AFM and SEM data we can observe the unpolished and polished sample. Form the polished sample we can observe the carbon nanofiber tips exposed. This preparation approach not only improves the electrical contact between the active sensing material (CNFs) and the conducting substrate, but also ensures that the sensor is free of impurities. The advantage of this technique is that the edges of the nanofibers are exposed and the CNFs are vertically aligned for the attachment of cholesterol oxidase.

Acknowledgments

Harriet Jenkins Pre-Doctoral Fellowship Program (JPFP) for the sponsor. Ramsey M. Stevens from Carbon Design Innovations for the CNT Tips.